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Research Article / Araştırma Makalesi

Effects of Thermal Cycles and Immersion in Different Beverages on Color, Translucency and Hardness of Different Composite Resins

Termal Döngülerin ve Farklı İçeceklere Daldırmanın Farklı Kompozit Reçinelerin Renk, Yarı Saydamlık ve Sertlik Üzerine Etkileri

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ABSTRACT

The aim of this study is to evaluate the color stability, translucency and hardness of eight different composite resins, after thermal cycling and immersion in beverages. Six light-cured dimethacrylate-based composite (Clearfil Majesty Esthetic, Clearfil Majesty Posterior, Grandio, Grandio Flow, Arabesk Top, Valux Plus), an ormocer (Admira) and a silorane-based composite (Filtek Silorane) were tested in this study. Fifteen samples (8x2 mm) from each composite were prepared. All samples were subjected to thermal cycling [(5.0 ± 0.5)~(55.0 ± 1.0) °C, 1000 cycles]. After thermal cycling, fifteen specimens in each group were divided into three subgroups (n = 5): distilled water (control), coffee, and red wine at 37°C for 30 days. With a spectrophotometer, the △E and Translucency Parameter (TP) were calculated against white and black backgrounds. Color, translucency and hardness of all samples were remeasured baseline, after thermal cycles and after immersion in beverages. The data were analyzed using repeated measured analysis of variance and Bonferroni multiple-comparison test (P<0.05). Red wine and coffee caused perceptible discolorations in all composite resin materials (△E>3.3). The effect of thermal cycles on color and translucency was not statistically significant (P>0.05). TP values generally decreased especially after immersion in red wine (P<0.05). Hardness values were varied among composite resins but generally decreased after thermal cycles and immersion especially in red wine. Thermal cycling and immersion in beverages caused to decrease in hardness values for composite materials. Because of negative effects on color and translucency, it should be noted especially red wine consumption.

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ÖZ

Bu çalışmanın amacı, sekiz farklı kompozit reçinenin termal döngüden sonra ve içeceklere daldırıldıktan sonra renk stabilitesini, saydamlığını ve sertliğini değerlendirmektir. Bu çalışmada altı adet ışıkla sertleşen dimetakrilat bazlı kompozit (Clearfil Majesty Esthetic, Clearfil Majesty Posterior, Grandio, Grandio Flow, Arabesk Top, Valux Plus), bir ormocer (Admira) ve silorane bazlı bir kompozit (Filtek Silorane) test edildi. Her bir kompozitten onbeş örnek (8x2 mm) hazırlandı. Tüm numuneler termal döngüye [(5.0 ± 0.5)~(55.0 ± 1.0) °C, 1000 döngü] tabi tutuldu. Termal döngüden sonra, her gruptaki on beş örnek üç alt gruba ayrıldı (n = 5): damıtılmış su (kontrol), kahve ve 37°C'de 30 gün boyunca kırmızı şarap. Bir spektrofotometre ile △E ve Yarı Saydamlık Parametresi (TP), beyaz ve siyah arka planlara karşı hesaplandı. Tüm numunelerin rengi, şeffaflığı ve sertliği, termal döngülerden sonra ve içeceklere daldırıldıktan sonra yeniden ölçüldü. Veriler, tekrarlanan ölçülen varyans analizi ve Bonferroni çoklu karşılaştırma testi (P<0.05) kullanılarak analiz edildi. Kırmızı şarap ve kahve, tüm kompozit rezin materyallerde (△E>3.3) hissedilir renk değişimlerine neden olmuştur. Termal döngülerin renk ve yarı saydamlık üzerindeki etkisi istatistiksel olarak anlamlı değildi (P>0.05). TP değerleri genel olarak özellikle kırmızı şaraba batırıldıktan sonra düştü (P<0.05). Sertlik değerleri kompozit reçineler arasında farklılık göstermiş ancak genel olarak termal döngülerden ve özellikle kırmızı şaraba batırıldıktan sonra düşmüştür. Termal döngü ve içeceklere daldırma, kompozit malzemeler için sertlik değerlerinin düşmesine neden olmuştur. Renk ve yarı saydamlık üzerindeki olumsuz etkileri nedeniyle özellikle kırmızı şarap tüketimine dikkat edilmelidir.

Introduction

Light can be reflected, absorbed, refracted and emitted when it reaches the tooth surface, as with any other object.[1] Natural tooth color is the result of a combination of light reflected from the enamel surface and emitted or reflected by dental hard tissues.[2] The most important factor in the success of an aesthetic material is that it imitates the natural tooth color and provides color stability.[3] Although the use of full-ceramic restorations undoubtedly provides good aesthetics; the disadvantages such as fragile structures, the necessity of indirect technique, and excessive wear in the opposing dentition have not been overcome accurately.[4] On the other hand, composites have been used in dentistry for many years to make successful restorations.[5]

The use of tooth-colored composite-resin materials, in addition to meeting aesthetic needs, is becoming widespread as a result of the possibility of conservative operation, short clinical study time, durable and economical treatment solution, and increasing the knowledge of patients about materials.[6] Recent updates in filler ratio, type and size have been of tremendous help in providing composite resin restorations with a more natural appearance.[7] With the evolution of nanotechnology, nano-sized (sub-micron) fillers have been included in dental composite resin materials. Optical and wear properties are improved, while mechanical properties remain at least comparable to conventional composites.[8, 9]

Aesthetic demands have created a need for dentistry to have information about color and its three-dimensional nature, as well as the factors affecting color stability.[10] The greatest requirement of the composite resin to be applied in the anterior region is to achieve a perfect color match with the natural tooth and to preserve its optical properties over time.[11] However, one of the most important disadvantages of these materials is their discoloration due to prolonged exposure to the oral environment. It has been determined that coloration occurs in these polymeric materials depending on internal and external factors.[12] Degradation of the resin matrix and the matrix-filler interface is the main cause of internal discoloration. In addition, factors originating from the material itself, such as the type of resin matrix, lower filler ratio, and incomplete polymerization can also be effective in internal coloration. It has been suggested that surface deterioration leading to the absorption of colored beverages and foods, smoking, and inadequate oral hygiene are the main causes of external discoloration.[13, 14] It has been reported that other factors causing the coloring of the composites are the strength of the polymerization device[15], the type of polymerization[16], UV rays[17], bleaching treatment[18], and polishing method.[19,20] Unacceptable color change is the primary reason for replacing anterior composite resin restorations.[10, 21, 22]

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Color identification methods mostly use a three-dimensional coordinate system that includes hue, chroma, and value. More subtle features such as tranlucency, opacity, opalescence, iridescence, surface gloss and fluorescence can be added to these features.[23] Translucency and opacity are accepted as the most important of these secondary features, which are indicators of the quality and amount of light reflection.[24] Translucency is often characterized as the fourth dimension of color and can be measured with a device similar to color. The translucency parameter (TP) is the color difference of a uniformly-thick material on a black and white background and expresses the ability of the material to mask the background. The translucency parameter ranges between 0 and 100. 0 indicates completely opaque material, 100 indicates completely transparent material.[25] When the color of a restoration is combined with appropriate translucency, it is possible to closely match the surrounding dental tissues.[26]

In recent decades, composite resins have evolved, but imitation of natural tooth color and color stability is still a clinical concern and an important area of dental research. For this reason, studies have been carried out to evaluate the color stability of the composite over time. In previous studies on color stability, it has been observed that different beverages, especially coffee, tea, and red wine cause coloration at varying rates. The probability of these beverages to cause color change differs according to their content and properties.[27, 28] Color and translucency changes of resin composites after aging protocols have been evaluated in many studies.[29-31] The durability of restorative materials in oral environment is closely related to their dissolution resistance. Various studies have shown that the erosive activity of acids in beverages can affect properties such as microhardness and water absorption, and thus the long-term success of restorations.[32] Moreover, the surface microhardness of a polymerized resin is an important physical parameter to show the color stability and degree of polymerization.[33]

To the best of our knowledge, there are only a few studies on the optical and mechanical properties of composites in different beverages and after thermal aging. Only one study investigated the correlation between color and surface hardness change in composites immersed in different beverages. The aim of the present study is to examine the effects of coloring beverages and thermal fatigue on color, translucency and surface hardness on different composite materials. The null hypothesis of the study is that beverages will not have an effect on the optical properties and surface hardness values of different composites.

Materials and Methods

In this study, 8 different composite materials were used and these materials are shown in **Table 1**. G*Power 3.1.9.4 software (Heinrich-Heine Dusseldorf University, Dusseldorf, Germany) was used to determine the sample size based on using the following parameters: 90% power, 0.25 effect size, and α error at 0.05. A minimum sample size of 5 samples for each subgroup was assessed to be appropriate.

Product	Manufacturer	Type	Content				Batch No.
			Organic Matrix	Fillers	Particle Size	Filler Load (wt-v)%	
Clearfil Majesty Esthetic	Kuraray Medical, Okayama, Japan	Nanohybrid	Bis-GMA, aromatic dimethacrylate	Silanated barium glass, filler, prepolymerized nano-organic filler	0.7 µm, 20 nm	78-66	00034A
Clearfil Majesty Posterior	Kuraray Medical	Nanosuperfilled	Bis-GMA, TEGDMA, aromatic dimethacrylate	Silanated glass ceramic filler, surfacetreated alümina microfiller	1.5 µm, 20 nm	92-82	0011OA
Grandio	VOCO GmbH Cuxhaven Germany	Nanohybrid	Bis-GMA, TEGDMA, UDMA	Glass-ceramic (microfiller) SiO_2 (nanofiller)	1 µm 20-60 nm	87-71.4	111720600,0%
Grandio Flow	VOCO GmbH Cuxhaven Germany	Flowable Nanohybrid	Bis-GMA, TEGDMA,	silicium dioxide, glass ceramic particles	SiO_2-nano particles (40 nm) glass fillers (1µm)	80.2-65.7	112740300,0%
Filtek Silorane	3M ESPE, St. Paul, Minn.	Silorane	Siloranes	Quartz, yttrium fluoride	0.47 µm	76	N132573
Admira	VOCO GmbH Cuxhaven Germany	Ormocer	Ormocer, Bis-GMA, UDMA	Ba-Al-B-silicate glass, SiO_2	0.7 µm	78-56	1034200
Arabesk Top	VOCO GmbH Cuxhaven	Microhybrid	Bis-GMA, TEGDMA, UDMA	Bariumaluminiumsilicate glass, Lithium aluminium silicate	0.7 µm	77-56	1051274
Valux Plus	3M ESPE	Hybrid	Bis-GMA, TEGDMA	Silanetreated ceramic	0.01-3.5 µm	80-71	N252857

Bis-GMA: bisphenol A glycidyl methacrylate; TEGDMA: triethylene glycol dimethacrylate; UDMA: urethane dimethacrylate

15 samples from each material were obtained using a 2 mm thick and 8 mm diameter stainless steel mold. A3 shade was chosen for each composite. The composites were placed in the mold and, celluloid tape and microscope glass were placed on the composite surface and held with finger pressure to obtain a smooth surface. Then, composite materials were polymerized using a LED polymerization device (Elipar Freelight II, 3M ESPE, St. Paul MN, USA) according to the manufacturer's recommendations. The light intensity of the polymerization device was checked with a radiometer (Hilux Ultra Plus Curing Units, Benlioğlu Dental Inc., Ankara, Turkey). The irradiance of halogen LCU was 600 ± 67 mW/cm2 with a wavelength of 450 - 520 nm. After polymerization, the surfaces of the samples were polished using polishing discs (Sof-Lex, 3M ESPE, St.Paul, MN, USA).

After the initial color and translucency measurements the samples were subjected to thermal cycling. (1000 cycles, waiting time 15 seconds, between 5 and 55°C). Color and translucency re-measurements were made and the samples were randomly divided into 3 sub-groups with 5 samples in each. Then, the samples were kept in coffee (Nescafe Classic , Nestle, Bursa, Turkey) or red wine (DLC Öküzgözü 2009, Doluca, İstanbul, Turkey) or in distilled water as a control. 2 g of coffee powder was dissolved in 200 ml of water that has just boiled and cooled for 1 minutes as per the manufacturer’s recommendation to prepare coffee. Samples were immersed in solutions for 3 hours a day, and were left in distilled water during the rest of the time. The measurements were repeated at the specified intervals.

Color measurement intervals:

- Initially when the samples are dry
- -After waiting 24 hours in distilled water
- -After the thermal cycle
- -After being kept in the coloring solution for 1 day
- -After being kept in the coloring solution for 1 week
- -After being kept in coloring solution for 15 days
- -After being kept in the coloring solution for 1 month

Translucency measurement intervals:

- Initially when the samples are dry
- -After waiting 24 hours in distilled water
- -After the thermal cycle
- -After the last period of coloration

Color measurements of the samples (Shade Pilot, DeguDent, Hanau-Wolfgang, Germany) were recorded as CIE L* a* b* value using spectrophotometer. The device was calibrated before starting the color measurement of each group. Measurements were made on a standard white background (L = 93.6 a= 1.5 b = -3.0) and the average CIE L* a* b* value was obtained by measuring 3 times from each sample. Color differences (ΔE) were calculated using the formula below.

$$\Delta E = \sqrt{[(L_2 - L_1)^2 + (a_2 - a_1)^2 + (b_2 - b_1)^2]}$$

The L1, a1 and b1 values represent the CIE L* a* b* values of the composite samples when they were initially dry, while the L_2, a_2 and b_2 values represent the CIE L* a* b* values measured in periods.

($\Delta L = L_2^* - L_1^*$, $\Delta a = a_2^* - a_1^*$ and $\Delta b = b_2^* - b_1^*$)

Translucency parameter (TP) were calculated using the formula below.

$$TP = \sqrt{[(L_B - L_W)^2 + (a_B - a_W)^2 + (b_B - b_W)^2]}$$

The CIE L* a* b* values of white background were L= 93.6 a= 1.5 b= -3.0, and black background were L= 19.4 a= 0.5 b= 2.5.

Vicker's diamond indenter was used in a microhardness tester (Micromet 2001, Buehler, Illinois, USA) for specimen indentation. For each microhardness test, two indentations were made at randomly selected locations (no more than 1 mm from the center) on the top and bottom surfaces of each specimen using a load of 50 g for 15 seconds. The average of the two measurements was calculated. All hardness values were expressed in Vickers hardness, where 1 HV=1.854 P/d2, with P being the indentation load and d the diagonal length.

Hardness measurement intervals:

- -After 24 waiting in distilled water (Initial)
- -After the thermal cycle
- -After the last period of coloration

The data were analyzed with repeated measured analysis of variance and Bonferroni multiple-comparison test (P<0.05) using a statistical software (SPSS 20, IBM Corp., Armonk, NY, USA).

Results

Tables 2-4 show the interactions among color, translucency and hardness values of composite resins baseline, after thermal cycles and after coloration respectively. Three-way repeated-measures ANOVA revealed that there were significant differences among the period, resins and the solutions used (distilled water, coffee and red wine) (P<0.05).

Generally the specimens stored in distilled water did not exhibit significant variance in the ΔE* and TP values. As an exception Filtek Silorane showed significant differences for both values after immersion in distilled water. After being immersed in coffee and red wine, all the products become darker (p<0.05). Translucency parameters and hardness values significantly decreased after red wine immersion for many composite resins. According to the results of the repeated measure ANOVA test, the interactions between materials, beverages and periods are all significant (p<0.05) (**Table 2,3,4**).

Table 2. Results of all interactions among the groups in terms of color change (ΔE^*_{ab}) values

Variation factors	df	Type III Sum of Squares	Mean Square	F	P
Resins	7	61.681	8.812	12.429	.001*
Beverages	2	1.980.795	990.398	1.396.976	.001*
Resins * Beverages	14	120.109	8.579	12.101	.001*
Error (Between samples)	96	68.060	.709		
Period	2	4.223.327	2.111.664	4.257.029	.001*
Period * Resins	14	205.146	14.653	29.540	.001*
Period * Beverages	4	3.839.564	959.891	1.935.101	.001*
Period * Resins * Beverages	28	245.230	8.758	17.656	.001*
Error(period)(Intra samples)	192	95.240	.496		

**P<.05 indicates statistically significant difference.*

Table 3. Results of all interactions among the groups in terms of translucency parameter (TP) values

Variation factors	df	Type III Sum of Squares	Mean Square	F	P
Resins	7	309.313	44.188	261.543	.001*
Beverages	2	30.866	15.433	91.346	.001*
Resins * Beverages	14	10.722	.766	4.533	.001*
Error (Between samples)	96	16.219	.169		
Period	2	171.070	85.535	167.690	.001*
Period * Resins	14	51.498	3.678	7.212	.001*
Period * Beverages	4	235.837	58.959	115.589	.001*
Period * Resins * Beverages	28	26.920	.961	1.885	.007*
Error(period)(Intra samples)	192	97.935	.510		

**P<.05 indicates statistically significant difference.*

Table 4. Results of all interactions among the groups in terms of hardness values

Variation factors	df	Type III Sum of Squares	Mean Square	F	P
Resins	7	261.305.419	37.329.346	2.873.637	.001*
Beverages	2	2.042.606	1.021.303	78.621	.001*
Resins * Beverages	14	8.190.239	585.017	45.035	.001*
Error (Between samples)	96	1.247.067	12990		
Period	2	44.645.072	22.322.536	1.647.335	.001*
Period * Resins	14	17.946.172	1.281.869	94.598	.001*
Period * Beverages	4	426.761	106.690	7.873	.001*
Period * Resins * Beverages	28	40.059.594	1.430.700	105.581	.001*
Error(period)(Intra samples)	192	2.601.733	13551		

**P<.05 indicates statistically significant difference.*

Red wine and coffee caused perceptible discolorations in all composite resin materials (△E>3.3) This discoloration was higher for Grandio Flow than other resins (**Table5**). The effect of thermal cycles on color and translucency of resins was not statistically significant (P>0.05) (**Tables 5 and 6**). The null hypothesis of the present study was partially rejected due to this result. (TP values of composite resins generally decreased especially after immersion in red wine (P<0.05). Hardness values were varied among composite resins but generally decreased after thermal cycles and immersion especially in red wine. (**Table 7**) (**Figure 1, 2, 3**).

Table 5. Mean (Standard Deviation) and multiple comparisons of ΔE*$_{ab}$ values baseline, after thermal cycles and coloration

Composite Materials	Solutions	Baseline	After TC	After Coloration	Mean Difference (Period 3-1)
Clearfil Majesty Esthetic	DW	0.78 (0.50)	0.74 (0.38)	0.66 (0.23)	-0.12
	CF	0.62 (0.23)	1.12 (0.28)	**4.06 (0.38)***	**3.44**
	RW	0.72 (0.29)	0.80 (0.16)	**19.84 (3.44)***	**19.12**
Clearfil Majesty Posterior	DW	0.52 (0.25)	1.24 (0.42)	0.70 (0.44)	0.18
	CF	0.74 (0.31)	0.96 (0.45)	**8.72 (0.70)***	**7.98**
	RW	1.16 (0.71)	1.36 (0.76)	**17.40 (1.34)***	**16.24**
Grandio	DW	0.80 (0.46)	1.86 (0.51)	1.30 (0.16)	0.50
	CF	0.60 (0.10)	1.34 (0.46)	**5.10 (0.58)***	**4.50**
	RW	0.72 (0.27)	1.56 (0.49)	**17.12 (0.71)***	**16.40**
Grandio Flow	DW	**0.48 (0.16)**	1.30 (0.26)	1.36 (0.11)	**0.88**
	CF	**0.58 (0.13)**	**1.48 (0.28)**	**9.26 (0.69)***	**8.68**
	RW	0.90 (0.10)	1.34 (0.72)	**24.36 (2.09)***	**23.46**
Filtek Silorane	DW	1.18 (0.55)	2.38 (0.91)	2.16 (0.51)	**0.98**
	CF	0.86 (0.11)	2.40 (0.65)	**3.76 (0.48)***	**2.74**
	RW	0.82 (0.40)	2.40 (0.48)	**13.58 (0.87)***	**12.76**
Admira	DW	0.40 (0.25)	1.30 (0.42)	1.28 (0.32)	0.88
	CF	0.84 (0.43)	1.38 (0.51)	**4.74 (0.69)***	**3.90**
	RW	0.80 (0.35)	1.56 (0.67)	**17.90 (0.85)***	**17.10**
Arabesk Top	DW	0.88 (0.66)	1.94 (0.65)	1.68 (0.81)	0.80
	CF	0.54 (0.40)	1.56 (0.63)	**3.56 (0.46)***	**3.02**
	RW	**0.40 (0.19)**	**1.56 (0.48)**	**17.52 (1.06)***	**17.12**
Valux Plus	DW	**0.56 (0.21)**	2.22 (0.81)	2.64 (0.76)	**2.08**
	CF	0.66 (0.35)	2.00 (0.92)	**6.40 (0.98)***	**5.74**
	RW	**0.54 (0.30)**	**2.82 (0.32)**	**16.14 (1.94)***	**15.60**

*Bold numbers in table represents statistical differences (p<0.05). (TC: Thermal Cycles, DW: distilled water, CF coffee, RW: red wine)*Indicates clinically unacceptable value (ΔE*ab<3.3)*

Table 6. Mean (Standard Deviation) and multiple comparisons of translucency parameter values baseline, after thermal cycles and coloration

Composite Materials	Solutions	Baseline	After TC	After Coloration	Mean Difference (Period 3-1)
Clearfil Majesty Esthetic	DW	14.72 (0.28)	14.24 (0.29)	14.50 (0.24)	-0.22
	CF	14.36 (0.49)	14.30 (0.44)	13.70 (0.52)	-0.66
	RW	14.82 (0.76)	14.62 (0.56)	**9.38 (0.90)**	**-5.44**
Clearfil Majesty Posterior	DW	13.54 (0.35)	14.04 (0.59)	13.72 (0.33)	0.18
	CF	13.40 (0.48)	13.20 (0.49)	**11.46 (0.97)**	**-1.94**
	RW	13.70 (0.29)	13.86 (0.80)	**9.48 (0.41)**	**-4.22**
Grandio	DW	17.60 (0.61)	17.46 (0.72)	16.88 (0.76)	-0.72
	CF	17.38 (0.25)	17.30 (0.38)	16.98 (0.69)	-0.40
	RW	17.26 (0.30)	16.92 (0.59)	**12.12 (0.95)**	**-5.14**
Grandio Flow	DW	16.66 (0.22)	16.64 (0.15)	16.78 (0.26)	0.12
	CF	16.74 (0.11)	16.72 (0.27)	15.82 (0.83)	-0.92
	RW	17.44 (0.43)	16.90 (0.57)	**14.36 (3.90)**	**-3.08**
Filtek Silorane	DW	11.04 (0.59)	11.32 (0.62)	**12.80 (0.24)**	
	CF	11.10 (0.60)	11.24 (0.63)	11.54 (0.70)	0.44
	RW	11.42 (0.47)	11.74 (0.22)	10.94 (1.42)	-0.48
Admira	DW	14.54 (0.21)	14.30 (0.51)	14.40 (0.37)	-0.14
	CF	14.66 (0.30)	14.00 (0.44)	13.72 (0.56)	-0.94
	RW	14.58 (0.74)	14.02 (0.35)	**10.74 (0.28)**	**-3.84**
Arabesk Top	DW	15.10 (0.48)	14.84 (0.60)	15.08 (0.52)	-0.02
	CF	15.14 (0.30)	14.92 (0.33)	14.54 (0.39)	-0.60
	RW	15.70 (0.48)	14.90 (0.69)	**10.72 (0.95)**	**-4.98**
Valux Plus	DW	14.54 (0.30)	14.12 (0.54)	14.08 (0.28)	-0.46
	CF	15.04 (0.45)	14.62 (0.65)	14.26 (0.39)	-0.78
	RW	14.50 (0.17)	14.38 (0.51)	**9.9 (0.73)**	**-4.60**

Bold numbers in table represents statistical differences (p<0.05). (TC: Thermal Cycles, DW: distilled water, CF coffee, RW: red wine)

Table 7. Mean (Standard Deviation) and multiple comparisons of hardness values baseline, after thermal cycles and coloration

Composite Materials	Solutions	Baseline	After TC	After Coloration	Mean Difference (Period 3-1)
Clearfil Majesty Esthetic	DW	56.4 (1.34)a	44.8 (1.10)b	38.8 (1.10)c	**-17.60**
	CF	51.2 (1.64)a	47.0 82.24)a	41.2 (1.10)b	**-10.00**
	RW	47.6 (2.19)a	50.2 (1.10)a	37.2 (0.45)b	**-10.40**
Clearfil Majesty Posterior	DW	162.4 (3.13)a	129.0 (4.47)b	111.8 (4.02)c	**-50.60**
	CF	134.0 (4.47)a	147.8 (7.12)b	105.2 (4.38)c	**-28.80**
	RW	141.8 (2.68)a	115.4 (4.93)b	97.8 (3.83)c	**-44.00**
Grandio	DW	113.2 (4.38)a	73.2 (1.10)b	103.6 (3.58)a	**-9.60**
	CF	130.0 (2.74)a	112.8 (14.79)a	84.4 (3.29)b	**-45.60**
	RW	133.2 (9.34)a	103.6 (3.58)b	69.6 (2.19)c	**-63.60**
Grandio Flow	DW	82.2 (4.92)ab	74.0 (2.74)a	80.0 (2.74)b	-2.20
	CF	110.0 (0.10)a	48.2 (2.17)b	65.6 (2.19)c	**-44.40**
	RW	110.0 (0.10)a	97.6 (2.19)b	57.0 (0.10)c	**-53.00**
Filtek Silorane	DW	68.8 (1.10)a	82.2 (4.09)b	73.0 (2.34)ab	4.20
	CF	83.4 80.89)a	66.4 (2.19)b	87.0 (5.39)a	3.60
	RW	101.6 (3.13)a	70.4 (2.19)b	35.8 (1.10)c	**-65.80**
Admira	DW	72.0 (0.10)a	45.8 (0.45)b	69.6 (2.19)a	-2.40
	CF	62.8 (1.64)a	45.2 (1.10)b	58.6 (2.19)a	-4.20
	RW	62.2 (1.64)a	51.6 (1.34)b	47.4 (0.55)c	**-14.80**
Arabesk Top	DW	81.0 (2.24)a	52.6 (0.89)b	43.6 (2.19)c	**-37.40**
	CF	101.0 (3.08)a	55.2 (1.64)b	71.4 (3.71)c	**-29.60**
	RW	69.2 (1.10)a	47.2 (1.64)b	44.8 (1.10)b	**-24.40**
Valux Plus	DW	134.0 (4.47)a	89.4 (6.02)b	113.6 (4.93)c	**-20.40**
	CF	135.0 (2.74)a	121.0 (4.47)b	80.0 (2.74)c	**-55.00**
	RW	139.2 (4.92)a	125.0 (5.48) b	87.0 (5.39)c	**-52.20**

Superscripts in same column represents statistical differences (p<0.05). (TC: Thermal Cycles, DW: distilled water, CF coffee, RW: red wine)

Filtek Silorane and Admira showed better results than methacrylate based composites in respect of the color, translucency and hardness (p<0.05) (**Tables 5-7**) (**Figure 1, 2, 3**).

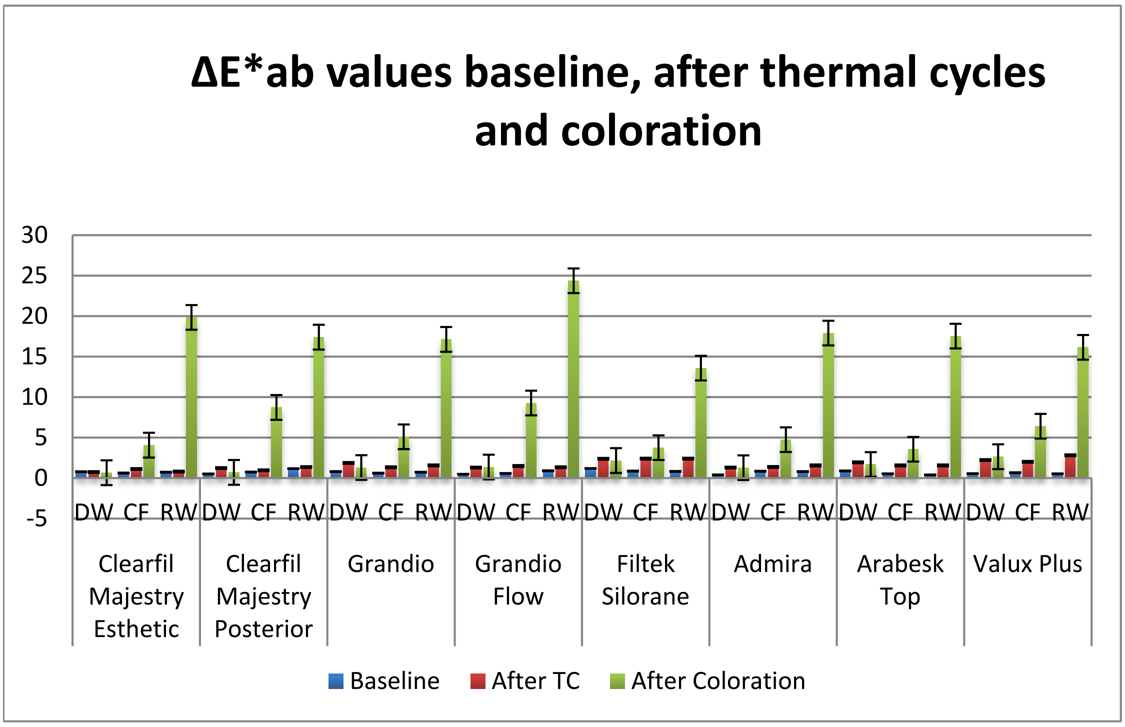

Figure 1. ΔE values baseline, after thermal cycles and coloration

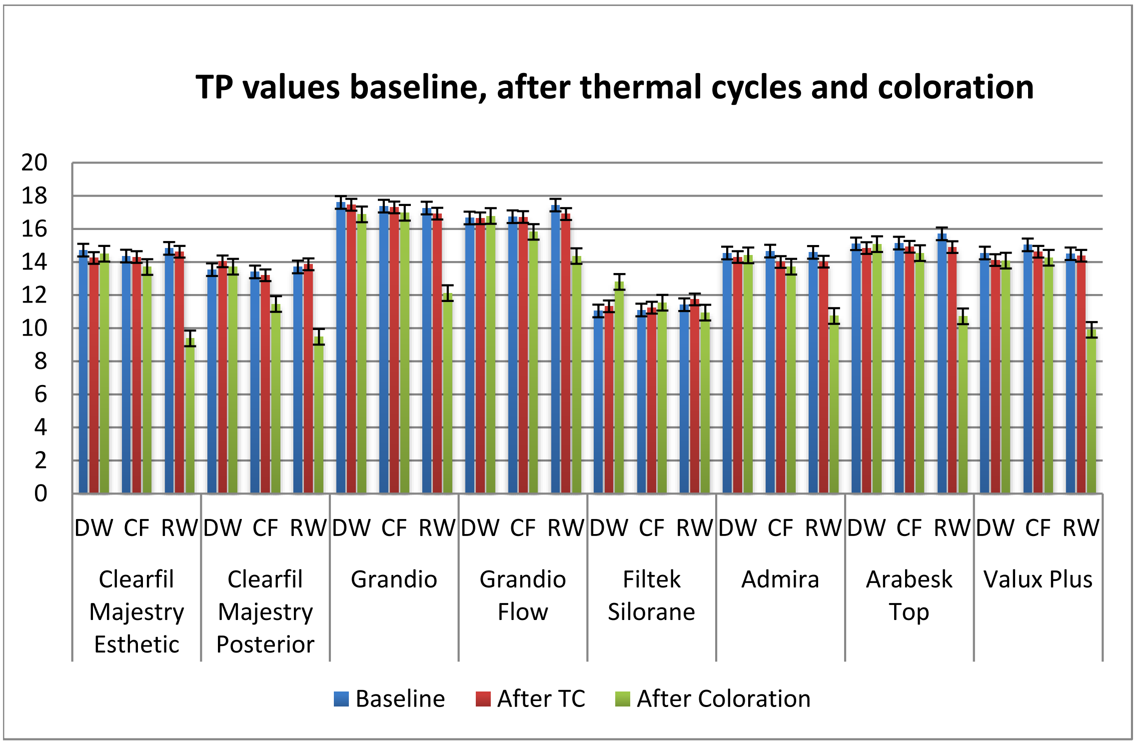

Figure 2. TP values baseline, after thermal cycles and coloration

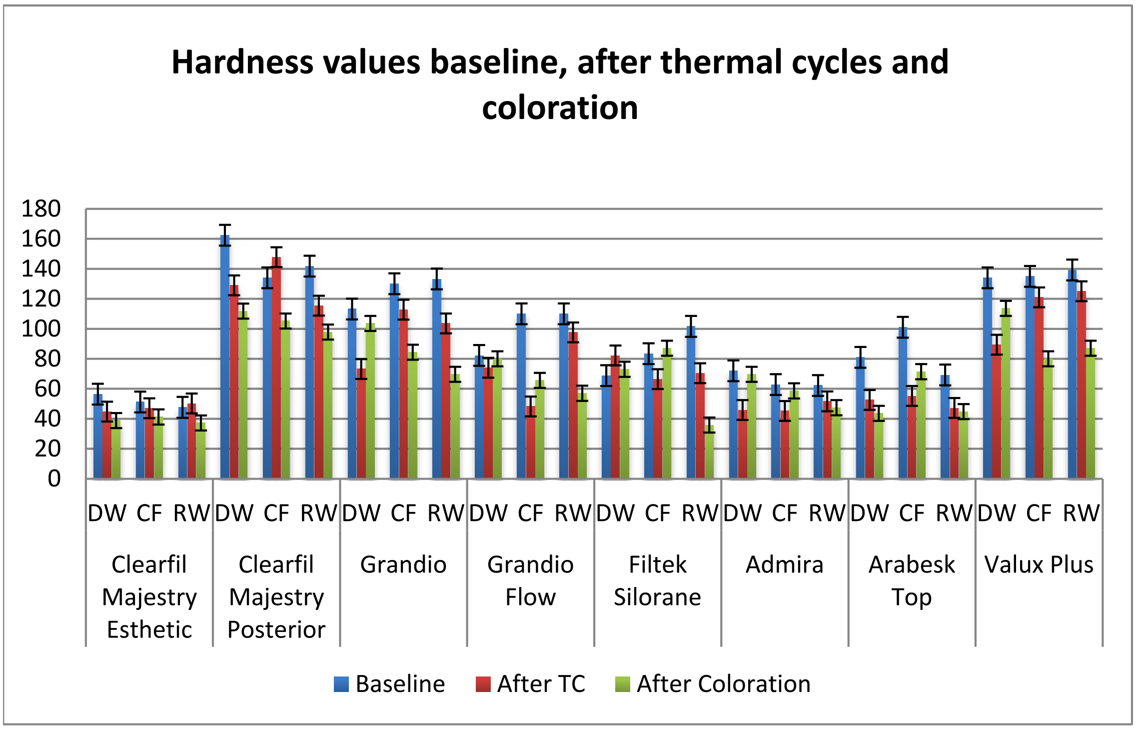

Figure 3. Hardness values baseline, after thermal cycles and coloration

Discussion

Composite resins, which started to be used in the field of dentistry in the 60s, gained popularity and became the first choice for anterior and posterior direct restorations.[34, 35] The life-span of composite restorations have been investigated and are seen as materials with acceptable performance, with a 1-4% annual failure rate. While the most important factor in failure is caries and fracture of tooth and/or restoration in posterior area, the aesthetic factor in anterior teeth plays an important role in the necessity of an intervention in the restoration for both dentists and patients.[36-38]

Color changes that occur over time in composite restorations are a challenge for dentists and the perception of color change may differ among patients. Since this situation is subjective, while it is not a problem for one individual, it may be a problem for another. On the other hand, Ruyter et al.[39] concluded that the clinically acceptable discoloration (ΔE) of a restoration should be less than 3.3. In the current study, although the color change at the end of one month showed a statistically significant difference for all composites kept in red wine and coffee compared to the control group (distilled water), these two coloring drinks gave results above 3.3. Thus, the null hypothesis of the study was rejected regarding color change. After thermal cycling, the color change in all composites did not exceed the clinical acceptability level. Kamheya et al.[40] also investigated the color changes of bulk-fill composites by keeping them in different beverages after thermal cycling. While there was no significant color change in the samples kept in water, they reported significant changes in ΔE values greater than 3.3 in samples aged in cola, coffee and red wine.

In this study, the color changes in the Grandio flow groups were found to be significantly higher than the other composites ($p<0.05$). Inorganic fillers in the structure of resin composites have better color stability than other components.[41] The fact that the inorganic filler ratio in the Grandio flow structure is less than many composite resins in the study partially explains this result. Choi et al.[42] investigated the color stability of Arabesk Top, Filtek Supreme and Tetric Ceram composites after thermal cycling and found ΔE values less than 3.3, consistent with our study. They claimed that the filler type was the cause for the Filtek Supreme, which showed the highest color change. It is known that the matrix and filler type and the matrix-filler interface affect the water absorption and color change of composites.

As human enamel has natural translucency, aesthetic restorations should also mimic the translucency of natural teeth.[43] Since translucency makes the restorations look more natural, it is one of the main factors that cannot be ignored in the construction of aesthetic restorations.[44, 45] Translucency, which expresses a state between full opacity and transparency, allows light to pass through the material and scatters it. Rather than reflection or absorption of light, it is dispersed in the material.[46] The object behind the material cannot be seen clearly.[47] Recently, fillers with sizes between 5-100 nanometers have been produced. Because these filler sizes are below the wavelengths of visible light (380-780 nanometers), nanofilled composites provide positive translucency, polishability and surface gloss.[21, 48] In addition, it has been reported that these materials show high translucency of nanomeric particles ranging from 20-75 nanometers on average, which is below the wavelengths of visible light.[49]

Composites show a "chameleon" effect in small cavities with the help of surrounding and underlying dental tissues.[15] However, especially in large class 3 and 4 cavities, composites with high translucency may appear too gray because they cannot hide the dark background of the oral cavity.[50] For this reason, it is more appropriate to use composites knowing their translucency properties. In addition, varying degrees of variability were observed in TP between resin composites after aging.[51] In terms of TP, it is known that composites show varying values after immersed in water, while TP of some composites increase, some of others may decrease.[52] In the current study, although the translucency values decreased slightly in the control group (except for Filtek Silorane), these values were not considered statistically significant. ($p>0.05$). Among other beverages, especially red wine significantly decreased the translucency values of the composites except Filtek Silorane ($p<0.05$). It can be said that both situations are caused by the different organic matrix structure of Silorane. Coffee caused a significant reduction only on the Majesty Posterior. The null hypothesis of this study was partially accepted in terms of translucency. The translucency of dental resin composites varies depending on their thickness, as well as the light scattering and absorbing coefficient of the resin, filler particles, color pigments and opacifiers.[53, 54] Different resin matrix and filler types may vary in color and translucency due to the influence of the content on the optical properties. Similar to the present study, Kaizer et al.[55] reported an increase or decrease in translucency in the composites (Filtek Supreme, Filtek P90, ROK) they used after 30 days of soaking in water. They reported that translucency decreased in all composites in red wine.

Restorative dental materials absorb water slowly, primarily due to the polar properties of the resin molecules. Water molecules infiltrating the polymer matrix affect the matrix-filling interface and polymer chains, resulting in reduced mechanical properties.[56] The properties of resin composites change after thermal cycling, and the effect of thermal fatigue differs with material properties.[57] In the present study, while the surface microhardness values generally decreased after thermal fatigue, soaking in coffee and red wine also caused additional decreases in these values. As a remarkable result, coffee caused a statistically significant increase on Grandio Flow, Filtek Silorane, Admira and Arabesk Top composite resins, which showed a decrease in surface hardness after thermal fatigue ($p<0.05$). This effect of coffee can be investigated in different studies. However, it should be noted that in the current study, similar to other studies, the surface hardness values of the samples kept in coffee decreased compared to the initial measurements.

Conclusion

The effect of red wine on color change and translucency of the composites was significantly greater than that of coffee and distilled water. In addition, the negative effect of coffee on these properties is undeniable which is showing clinically unacceptable ΔE values in all solutions. Generally hardness values reduce after thermal cycle and colorant agents. The effect of all solutions are similar, with a slight difference in red wine.

Değerlendirme / Peer-Review

İki Dış Hakem / Çift Taraflı Körleme

Etik Beyan / Ethical statement

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It is declared that during the preparation process of this study, scientific and ethical principles were followed and all the studies benefited are stated in the bibliography.

Benzerlik Taraması / Similarity scan

Yapıldı – ithenticate

Etik Bildirim / Ethical statement

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Çıkar Çatışması / Conflict of Interest

Yazarlar çıkar çatışması bildirmemiştir. | The authors have no conflict of interest to declare.

Yazar Katkıları / Author Contributions

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Veri Toplanması | Data Acquisition: ÖS (%40), PG (%60)
Veri Analizi | Data Analysis: ÖS (%35), PG (%65)
Makalenin Yazımı | Writing up: ÖS (%60), PG (%40)
Makale Gönderimi ve Revizyonu | Submission and Revision: ÖS (%80), PG (%20)

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